Market Dominance and Pricing in a Spatial Environment: An Empirical Examination of Railroad Pricing with Competitive Pressures†

by

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Abstract: Since the passage of the Staggers Act in 1980, the rail industry has become increasingly consolidated. Because of this consolidation, many shippers have become "captive" as there may be only one railroad serving their location and no feasible alternative mode of transportation available. At these locations, without competition from either other railroad companies or other modes of transportation, the railroad has the ability to spatially price discriminate over that section of its network. In this study, a model of market dominance is applied to rail pricing data to examine railroad pricing under different competitive pressures. The findings of this analysis suggest that railroad firms do respond to competition from the barge market and this response varies across markets. The magnitudes run to about a a 10.3% difference between the rail rate per car of a firm located at a barge loading facility and another firm located 700 miles away from its closest barge terminal. Aggregated over a 50-car shipment, this implies a $9,473 to $16,123 cost difference attributable solely to differences in the competitive pressure provided by the barge market.

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1. Introduction

Prior to the Staggers Act of 1980, most if not all rail rates, routes and mergers were all governed by the Interstate Commerce Commission (ICC). Following the passage of the Staggers Act, there is widespread evidence that rail rates fell and efficiency improved.[1] One source of these cost savings and improved efficiency arises through mergers. Mergers of rail firms have reduced the amount of Class I railroad companies from 39 in 1980 to seven in 2006. The increase in concentration, however, seriously limits the number of options available to shippers with the result that many shippers are captive to the single railroad that serves their location or locations nearby. Generally shippers have options defined by the origin or destination of the movement and by the mode or modes to or from which the movement travels. In this paper, we develop and estimate a model of railroad pricing given the options available to shippers. In our model, the railroad must be the preferred alternative by the shipper at the rate it charges. This serves as a constraint on railroad pricing. The result of the model is that the railroad prices a shipper at the monopoly rate or the rate implied by the next best alternative.

A focus of this study is on the intermodal competition between rail and barge. The classic result of MacDonald (1987) is that competition from the waterway, aided by truckers, serves to constrain rail rates. In addition, however, there are other competitive elements which may also limit railroad pricing. These include alternative markets for the product shipped, other railroads etc. To examine these relationships we collect rail pricing data directly from the railroad websites. The market that we analyze is that of corn shipments from various locations in states that are either first or second degree

[1] For studies on the effect of Staggers on rates see Wilson (1994), Burton (1993), McFarland (1989), Barnekov and Kleit (1990) and Boyer (1987). Wilson (1997), Berndt et al (1993) and Vellturo et al (1992) are good examples of similar studies examining the impact of deregulation on costs and productivity.

contiguous to the Mississippi River System. The rates are collected for shipments to both the Pacific Northwest and the Gulf Coast. The results indicate that rail prices per car can be as much as 10.3% higher based solely on the distance to the waterway. This implies as much as a $9,473 to $16,123 cost savings attributable to barge competition.[2] We also find that there are modest differences that accrue from different terminal locations. Our model also controls for a major change in the corn markets. Specifically, over the last several years, the ethanol market has evolved as a major outlet for corn. Corn is a primary input in the production of ethanol and the quantities of ethanol produced have increased dramatically in the last five years. Much of the ethanol capacity has evolved in locations near the Mississippi river system and points to an alternative destination for corn and another constraint on railroad pricing of corn shipments destined for the Pacific Northwest and Gulf Coast. The results suggest that ethanol, while still an emerging industry has a significant effect on railroad pricing, and that further growth of this industry will continue to impede the ability of railroads to spatially price discriminate.

Spatial price discrimination has a long history in economics literature. Much of this research has been theoretical in nature, e.g. Holahan (1975), Greenhut and Greenhut (1975), Greenhut and Ohta (1979), Norman (1981), Hobbs (1986), Thisse and Vives (1988), Anderson and de Palma (1988) and Anderson, de Palma and Thisse (1989). However, new data sets have made the empirical estimation of spatial price discrimination feasible with examples including Greenhut (1981) who examines

[2] In corn markets this is particularly important in that profit margins are often quite low.

differences in spatial price discrimination across counties and Lindsey and West (1997) who look at the use of parking coupons.[3]

MacDonald (1987) and Burton (1995) each examine the effects or the waterway on railroad pricing.[4] Both of these studies use the ICC's Annual Rail Waybill data set.[5] MacDonald (1987) incorporates two measures of barge competition in the rail market including the distance between each originating point and the nearest waterway and a dummy variable for "port" locations that are less than a mile from the waterway. Using this specification, MacDonald (1987) finds that the rail rate charged increases as one moves away from the river.[6] MacDonald (1987) also finds that the rail rate is higher for "port" locations located within one mile of the waterway.[7] Rather than using the distance from the waterway as a measure of barge competition, Burton (1995) includes a dummy variable for the availability of barge transportation. Applying this model to Waybill data from 1973-1987, Burton (1995) finds that the existence of barge as an alternative reduces the rail rate for food products, for non-metallic minerals, and for clay, concrete, glass and stone products. However, the effect of water is found to be insignificant for coal, metallic ore, chemicals, and scrap materials.

This current study frames the railroad pricing decision in terms of model of market dominance where the railroad's pricing decision is constrained by the existence of

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[3] For a detailed survey of the spatial price discrimination literature, see Phlips (1983), Greenhut, Norman and Hung (1987) or Varian (1989).
[4] Note that Wilson, Wilson and Koo (1988) look at the pricing of railroads with market power in the presence of the truck market as a competitive pressure.
[5] MacDonald (1987) uses the Waybill Sample Master while Burton (1995) uses the Waybill public file.
[6] MacDonald (1987) finds that rates for wheat shipments are 40% higher for a shipper located 400 miles from the river than for a shipper located 100 miles from the river. The estimated effect for corn and soybeans, while significant, are much smaller with a 1% increase in the distance from the water increasing revenue per tonmile (rate) by .086 for both corn and soybeans, a result similar to that found in this study.
[7] Note that this finding could be indicating that the railroad is pricing a monopoly segment of an intermodal movement as is demonstrated by Burton and Wilson (2006).

barge transportation to arrive at an empirical model of rail rates. Data consisting of available rail rates between separate origin-destination combinations are then used to estimate this empirical model. Previous studies of railroad pricing all employ a subset of the Waybill data; however, there are several well established shortcomings to using these data to study this problem depending upon which version of the Waybill data is being used (e.g. Wolfe (1986), Wolfe (1991) and Wolfe and Linde (1997)). The primary complication with using the Waybill data comes from the masking of the rates done by the Surface Transportation Board, whereby the railroad's rates may be altered in situations where identification of the railroad in question is likely. In addition, there is also a more basic complication with using these data to examine the impact of the barge market on the rail market. Because the Waybill data contains the profit-maximizing decisions of shippers using rail there is a selection problem in examining the interaction between rail and barge. That is, the Waybill data only contains information on individuals for whom rail was the least cost alternative, excluding observations where rail priced itself out of the market. Additionally, the focus of the previous studies using Waybill data is on the existence of barge transportation, with no ability to control for whether barge can service the same route as rail, which may also impact the ability of the barge industry to compete with rail. This study avoids the complications of using Waybill data, while also accounting for competitive pressures from an alternative market, ethanol.[8]

[8] It should be noted that the data used in this analysis were collected directly from the railroads, and therefore there is no accounting for how much traffic is moved under these rates, a pitfall of using these data versus the Waybill data. However, the rates used in this analysis match closely with the average rates published in the weekly USDA Grain Transportation Report.

The results of this study are also of import to policy-makers as it calls into question assumptions behind models currently being used by the Army Corps of Engineers for the benefit analysis of waterway improvements.[9] These models typically assume that increases in the barge rate due to congestion on the waterway will lead to shipments switching from barge to rail without a response in railroad price. In other words, these models assume that rail rates are exogenous and not influenced by the barge industry. This is an assumption directly called into question by the results of this study, which indicate that the pricing decisions made by railroads are constrained by the availability of barge transportation.

The remainder of this study is divided into four sections. Section 2 presents a theoretical model of dominant firm pricing with heterogeneous goods. Section 3 then develops an empirical model stemming from the theory and discusses the data used in this analysis. Section 4 presents the results of this study, while Section 5 offers concluding comments.

2. Theoretical Model

For shippers of grain, there are three available modes of transportation of which they will use some combination in order to get their crops to one of several potential markets: truck, rail or barge. Due to the costs of service, truck rates tend to be higher than either rail or barge especially for longer distances. However, truck also provides the quickest method of transportation, thus reducing inventory costs. Of most importance to this study, truck also provides a mechanism through which shippers, without direct access, can access other, lower cost, modes of transportation e.g., barge, unit trains, etc. For

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[9] Note that many of these assumptions have been called into question previously by the National Academy of Science (NRC 2001, 2004).

shifpments going beyond the local market, say to an export market such as the Gulf Coast or the Pacific Northwest, rail and barge compete for shipments. However, for shipments originating off of the waterway system, truck is commonly used to move the commodity to a barge loading facility. Because of this reliance on the higher cost trucking industry, the barge industry's ability to compete with rail depends on the distance between the origin and the waterway, i.e. the truck distance of the truck-barge movement.[10]

From the railroad's perspective, their ability to spatially price discriminate is constrained by the level of competitive pressures at their location. These pressures may take many forms, including: the ability of barge to compete with rail at any particular location, which in turn, is a function of the distance to the waterway, the capacity of local ethanol plants, other railroads servicing the location, etc. The railroad's problem is then to charge the highest rate possible at each location subject to procuring the shipment, i.e. subject to the shipper choosing rail as their mode of choice. This model follows from Wilson (1996) who used it to examine market dominance principles in regulating railroad rates.

Shippers have a variety of alternative markets (*d*) where they can sell their product and there are typically a variety of modes choices available to them either directly or through interchange. These alternative shipment plans are denoted by *m*. The initial starting point is to frame the discrete choices of a price-taking shipper. For each option available to the shipper, there is an associated maximum profit given prices represented in a profit function. This function is given by $\pi_{md} = \pi(P_d, r_{md})$ where *m* defines the modal choice, P_d represents the price received at market *d*, and r_{md} represents

[10] The appropriate model for this type of competition is a model of market dominance ala Wilson (1996).

the transportation rate by modal option *m* to market *d*. Given each shipper has multiple mode/destination choices, they then choose the option that gives the highest profit level.

$$\underset{m,d}{\text{Max}}\ \pi = \pi_{md}(P_d, r_{md}) \tag{1}$$

By Hotelling's Lemma, the demand for transportation by mode *m* to destination *d* can be derived from equation (1) as:

$$\frac{\partial \pi}{\partial r_{md}} = -X_{md}(P_d, r_{md}) \tag{2}$$

In the specific case of rail to a particular destination, the demand is $X_{Rd}(P_d, r_{Rd})$. The railroad takes this demand function as given, and chooses the rate that maximizes its profit subject to the constraint that shipper must prefer the option involving railroad over other options. This means that the railroad's maximization problem may be constrained by the existence of alternative modes of transportation and/or destination options.

The railroad's profit maximization problem is:

$$\begin{aligned} \underset{r_{Rd}}{\text{Max}}\ \pi &= r_{Rd}X_{Rd}(P_d, r_{md}) - C(X_{Rd}(P_d, r_{md})) \\ &\text{s.t. } \pi_{Rd} \geq \pi_i\ \forall\, i \neq rd \end{aligned} \tag{3}$$

Where $C(X_{Rd}(P_{dq},r_{mdq}))$ is the railroad's cost associated with the demand resulting from its choice of rail rate r_{Rd}. Notice that the constraint on the railroad's maximization problem given by equation (3) requires that the profit received by the shipper from utilizing rail is greater than, or equal to, the profit it obtains from any alternative mode of transportation *i*, i.e. the railroad procures the shipment.

The Lagrangian for the railroad's profit maximization problem given by equation (3) is:

$$L = r_R X_R(P_d, r_{md}) - C(X_R(P_d, r_{md})) + \lambda(\pi_R - \pi_i) \tag{4}$$

With the first order conditions given by:

$$\frac{\partial L}{\partial r_R} = X_R(P_d, r_{md}) + r_R \frac{\partial X_R(P_d, r_{md})}{\partial r_R} - MC \frac{\partial X_R(P_d, r_{md})}{\partial r_R} + \lambda \frac{\partial \pi_R}{\partial r_R} \leq 0 \qquad (5)$$

$$\frac{\partial L}{\partial \lambda} = \pi_R - \pi_i \geq 0 \qquad (6)$$

There are a number of results. The railroad must be the low cost mode of transportation to procure the shipment. Given that the railroad is the low cost mode, it prices at the maximum of the monopoly price or the constrained price. That is, the railroad prices at the monopoly level unless it is constrained by other alternatives that the shipper would choose at the monopoly price. If the railroad is the low cost producer and is constrained by the presence of alternatives, it prices between the monopoly price and marginal cost. In this model, the railroad charges different rates for movements that originate at different locations. The differences depend not only on cost differences but also on competitive pressures present at any given location. Since these pressures likely vary across spatial dimensions e.g., truck-barge is less attractive to shippers as the truck share of the movement increases, i.e. the railroad spatially price discriminates over shippers. In addition, as noted earlier, over the last several years, ethanol plant locations have evolved as an option for corn shippers. In this model, this adds another alternative available to shippers, and we expect that rail rates near ethanol locations will be affected.

The first-order condition can be rewritten in a convenient form to evaluate markups and to help frame the empirical model. That is, equation (5) can then be rewritten as:

$$(r_{Rd} - MC)\frac{\partial X_{Rd}(P_d, r_{Rd})}{\partial r_{Rd}} = (\lambda - 1) X_{Rd}(P_d, r_{Rd}) \qquad (7)$$

Or,

$$\frac{r_{Rd} - MC}{r_{Rd}} = \frac{(\lambda - 1)}{\varepsilon} \tag{8}$$

where ε is the price elasticity of the demand for railroad service. Notice that the left-hand side of equation (8) represents the difference between the rail rate and marginal cost, i.e. the Lerner Index of market performance.

Equation (8) indicates that railroad's profit-maximizing rate is either the competitive rail rate $r_{Rd} = MC$, ($\lambda = 1$), the monopoly rate ($\lambda = 0$), or at some point between the competitive and the monopoly levels. Specifically, the railroad's profit maximizing rate, r*, is a function of the restrictiveness of the constraint that the railroad's rate be high enough to procure the shipment, λ. Put another way, the railroad's profit maximizing rate deviates from marginal cost pricing by a "markup" which reflects constrained market dominance as defined by Wilson (1996).[11]

En route to an empirical model, equation *(8)* can be written as:

$$r^*_{Rd} = \frac{MC}{1 - \frac{(\lambda - 1)}{\varepsilon}} \tag{9}$$

Which then can be written as:

$$\log\ (r_R) = \log\ (MC) - \log\ (markup)\ \ (10)$$

[11] Note that Wilson (1996) used this model to assess the Interstate Commerce Commission's market dominance rules. These rules stated that the reasonableness of a railroad's rates could only be considered if the rates were first found to be market dominant.

where *markup* = *f*(λ, ε). Note that the markup term, representing the level of market dominance, is measured by lambda, which reflects the difference in profits between shipper alternatives and railroad cost dominated traffic. This difference depends critically on the spatial environment of these shipping alternatives. In particular, for shippers located near the waterway or ethanol plants, or that have alternative modes of transportation available, the railroad must lower its rate to procure the traffic. As these alternatives become less competitive, the attractiveness of each alternative relative to rail service dissipates and the railroad gains greater pricing power. Therefore, the test stemming from this theory is whether the railroad's pricing decision varies with the restrictiveness of competitive pressures.[12] If so, one would expect the railroad to have market dominance at locations where there are fewer competitive options available to shippers.

3. Empirical Model & Data

The empirical model follows directly from equation (10) above, where the demand for rail transportation, and the subsequent price charged by railroad companies, are functions of cost characteristics, demand determinants and competitive environment variables. We specify this model with a logarithmic form as:

$$\begin{aligned}\ln(\text{Price per Car}) = \alpha_0 &+ \alpha_1 \ln(\text{capacity}) + \alpha_2 \ln(\text{distance}) + \alpha_3 \text{Unit Train} \\ &+ \alpha_4 \ln(\text{distance to waterway}) + \alpha_5 \text{Direct Barge Access} \\ &+ \alpha_6 \text{Rail Competition} + \alpha_7 \text{Ethanol Capacity} \\ &+ \alpha_8 \text{Pacific Northwest} + \mu \end{aligned} \tag{11}$$

The dependent variable for this analysis is the rail rate per car for firm i to destination j by carrier k, measured in dollars. Cost measures for each firm include: the

[12] Note that empirically, the competitive differences include the distance from the waterway (used to capture the competitive pressure from the barge market), the number of railroads able to serve the particular origin, and the capacity of ethanol surrounding the shipper.

capacity (measured in tons) of the shipment, the distance (measured in miles) of the shipment and whether the shipment is part of a unit train or not.[13] It is assumed that increases in capacity lower the rail rate per car while larger shipments have a minimal effect on the railroad's costs given that it is already moving between two points. Longer shipments are assumed to increase the rail rate per car because a large share of the firm's costs is directly related to the distance being traveled. Finally, movements by unit train are assumed to decrease the rate per car.[14] In addition to these cost variables, competition variables, which represent the markup term derived previously, include: the distance (measured in miles) from the origin to the nearest barge loading facility, a dummy variable for whether the warehouse itself has barge loading capabilities, the number of competing railroads serving the particular warehouse with the ability to ship to either the Gulf Coast or the Pacific Northwest, the capacity of ethanol plants located within 60 miles of the originating warehouse (measured in millions of gallons per year), and finally a dummy variable for the Pacific Northwest.[15] Note that the inclusion of the dummy variable for the Pacific Northwest is used because barge transportation is not possible between the origins listed in Figure 1 and the Pacific Northwest, providing the railroad(s) serving these locations additional market power compared to shipments destined for the Gulf Coast where barge, or more accurately truck-barge, is an option.

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[13] These cost measures are common to this literature, e.g. MacDonald (1987). The rail rates collected from each railroad company vary based on the quantity being shipped. Capacity in this study is measured as the average quantity that can be shipped at the given rate.

[14] A unit train is a shipment of a set amount of cars where one shipper uses all of the cars in the train rather than multiple shippers each using portions of the train.

[15] Ethanol capacity was collected in twenty mile increments extending out 200 miles from the origin facility. The results presented in this study are robust across all of these measures of ethanol capacity, thus a 60-mile radius was chosen because corn must be transported to the ethanol facilities, usually by truck, and the cost of transporting the corn more than 60 miles may make the farmer unlikely to choose this option.

Equation (11) is estimated via OLS and firm specific fixed effects with an interaction term between the distance to waterway and Pacific Northwest variables to examine whether the effect of the barge market on the rail rate being charged differs by destination.[16] The mean values for each of the variables included in equation (11) are presented in Table 1. Due to the aforementioned observation that the effect of barge transportation may have differing effects on shipments destined for Pacific Northwest versus the Gulf Coast, means values are also presented by destination group. Notice that shipments headed to the Pacific Northwest have higher average rail rates ($3834.50 versus $3168.90), travel a further average distance to their destination (1935.7 miles versus 1312.5 miles) and are also, on average, located further from the waterway (231.21 miles versus 205.85 miles). In addition, the mean values for each variable are presented by the distance to the waterway in Table 1. Note that the average rail rate per car is $488.80 higher for the 25% of observations located furthest from the waterway when compared to the 25% of observations located closest to the waterway.

The data used for this analysis originate from warehouse locations identified by the Farm Service Agency (FSA).[17] In particular, a random sample of locations in states that are either first or second degree contiguous to the Mississippi River System is drawn from the universe of warehouses listed by the FSA. These warehouses are shown in Figure 1, and contain observations in North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Missouri, Iowa, Minnesota, Illinois, Indiana, Kentucky and Tennessee.

[16] Other specifications were estimated including higher order terms of the distance to the waterway and state level fixed effects. In addition, specifications were explored using the rail rate per mile as the dependent variable. The results presented here are qualitatively unchanged across these different specifications.

[17] Note that the Secretary of Agriculture licenses all warehouse operators who store agricultural products according to the U.S. Warehouse Act. Therefore the raw data used for this analysis should include all warehouses used to store/ship agricultural commodities.

As the focus of this study is on shipments of corn originating from these warehouse locations, Figure 1 also illustrates the most common destinations for grains: the Gulf Coast (New Orleans, LA) and the Pacific Northwest (Portland, OR).

Using the warehouses in Figure 1 as the origin, rail rates for the shipment of corn are collected between each location and either Portland, OR and/or the Gulf Coast.[18] These rail rates are collected directly from the railroad via its website. Given an origin and destination, these websites allow for the query of rates. Along with reporting the rate for the shipment in question, information is also reported about the length (in miles) of the movement on the railroad's network and how the rate varies based on the quantity shipped. All available rates are collected for each location, meaning that each origin may have multiple rates based on volume discounts and/or destination.[19] The average rate for each of these origins is shown geographically in Figure 2. Note that the average rail rate increases as one moves north and/or west, i.e. as distance from the Mississippi River, with the highest average rates being for locations in western North Dakota.

In addition to the information provided by the railroad itself, other rail demand variables are added. Of principle importance to this study is the distance to the nearest barge loading facility from the origin. The U.S. Army Corps of Engineers' port facilities database contains every such facility, and GIS software is used to both determine the closest facility and to calculate the distance between that facility and the warehouse

[18] Note that because of network differences, some rail providers are capable of shipping to the Gulf Coast but not New Orleans, LA. Therefore, some of the rail rates are to Mobile, AL or Houston, TX instead of New Orleans, LA.

[19] Many rail movements are transported by shuttle trains which are shipments of more than 100 cars that meet railroad requirements. The U.S. Department of Agriculture's (USDA) weekly Grain Transportation Report contains information on shuttle train rates versus unit train rates. In comparing the shuttle train rates contained in these reports with the rates collected for this study, the shuttle train rates are similar, but always below the unit train rates collected here; however, there is little variation in the difference across origin/destination combinations.

location.[20] Other than barge competition, the railroad also faces competition from other railroads. The inclusion of a measure of rail competition is simplified in this study by the observation that part of the FSA's warehouse database contains information on what railroad companies serve each particular warehouse.[21] A final competitive pressure faced by railroads is the emergence of ethanol which provides for an alternative destination for corn. To control for the presence and impact of ethanol, the capacity of ethanol plants located within 60 miles of the origin facility are collected from the U.S. Department of Energy.

4. Results

The results of the OLS and firm specific fixed effects specifications of equation (11) are presented in Table 2. While the OLS specification fits the data well with an r-squared of .74, the firm specific fixed effects model does a much better job with an r-squared of .95. Additionally, tests for the appropriateness of the firm specific fixed effects indicate that such a specification is warranted at the 1% level of significance. Also important is the stability of the estimates across these two models, with almost all estimated coefficients being numerically identical.

In terms of the effect of the cost variables on rail rates per car, all three coefficients are statistically significant at the 1% level of significance in each specification, and all three have the expected sign.[22] That is, larger shipments, i.e. higher capacity, lead to a reduction in rail rates as the increased cost from an additional ton is

[20] The distance between each warehouse and the nearest port facility is calculated as a straight line distance because there is no address for each warehouse given in the FSA database. However, attempts to estimate the distance as a route distance were made and did not influence the results or conclustions.
[21] Note that in the raw data, only 11.5% of the warehouses are served by 2 or more railroads, while only 1.4% have more than 3 rail alternatives.
[22] MacDonald (1987) has a detailed discussion of the expected signs of the cost measures.

minimal; longer shipments lead to an increase in rail rates as the added length to the shipment increases costs; and the rate per car for unit train shipments is lower than for other shipments. In particular, using the fixed effects results presented in Table 2, a 1% increase in capacity leads to a .0455% decrease in the rail rate per car. Likewise, a 1% increase in the distance of the shipment leads to a .3474% increase in the rail rate per car. Similarly, sending a shipment as part of a unit train is found to reduce the rail rate per car by 5.9%.

The estimated effect of barge transportation on rail rates is captured in two estimates presented in Table 2. First, the effect of proximity to water as captured by the distance to the nearest barge loading facility is positive and significant in both specifications. This means that a 1% increase in the distance to the nearest water port increases rail rates per car by .004 to .008 percent.[23] Meaning that if we took the origin located closest to a barge loading facility and the origin located the furthest from a facility, at the mean values of all other variables, the warehouse located farthest from the waterway would face 3.1% to 6.6% higher rail rates per car. Aggregated over a 50 car shipment this would imply a cost difference of $4,957 to $10,295, attributable solely to the distance from the waterway. In addition to the effect of the distance from the waterway on rail rates, the estimated effect of having direct, onsite, barge access is a decrease in rail rates of between 2.8 and 3.7 percent.[24] Combining the results on the

[23] In alternative specifications using the rate per mile as the dependent variable, the results suggest that a 1% increase in the distance to the nearest water port increases rail rates per mile by 0.004%, a result remarkably similar to that found using the rate per car.
[24] Note that the distance to the waterway was calculated as the distance between each originating point shown in Figure 1 and the nearest grain shipping port facility in the U.S. Army Corps of Engineers' database. The FSA data contains information on whether there is direct barge access at the location, which is where the direct access dummy variable comes from; however, since little information is provided on the barge loading facilities at the warehouse, the distance to nearest facility is left as the distance to the nearest grain loading facility in the U.S. Army Corps of Engineers' database.

distance from the waterway and the direct access variable, rates are found to be as much as 10.3% higher due solely to barge competition, which implies a cost difference of $9,473 to $16,123 for a 50-car shipment.

This estimated relationship between the distance to the nearest barge loading facility and rail rates is perhaps easiest seen graphically for observations within 100 miles of the waterway in Figure 3 or geographically for all observations in Figure 4. Both figures show the predicted rail rate per car at the mean values of all other variables versus distance to water. Figure 3 graphically shows that rail rates increase dramatically with increased distance to the waterway, with almost all of the increase occurring in the first 50 miles. Because shippers use the higher priced trucking industry to access the waterway from off-river locations, this result makes intuitive sense as the ability of barge transportation to compete with rail also decreases dramatically as one moves away from the waterway. Figure 4 shows the same relationship, but geographically, which allows for the identification of the specific areas impacted by this pricing strategy, with North Dakota feeling the strongest impact.[25]

While competition from the barge industry proved to have a significant impact of rail rates per car, the other measures of competitive pressures are less conclusive. Rail competition is not significant in either specification; however, this should not be surprising as very few warehouses were served by multiple railroads with networks servicing the Pacific Northwest and/or the Gulf Coast. The capacity of ethanol production was included to capture an alternative destination for corn. In the OLS

[25] Note that because the focus of this study is on warehouses located close to the waterway (1st or 2nd degree contiguous), there are no warehouses from Montana. However, the most notorious case in market dominance is the McCarty Farms case in Montana, in which Burlington Northern was found to have market dominance and charge excessive rates to shippers in Montana.

specification, the effect of ethanol capacity is negative and significant indicating that railroad rates per car fall as the local demand for the commodity increases; however, the estimates under the fixed effects specification are insignificant. Finally, the dummy variable for shipments destined for the Pacific Northwest is positive in both specifications, but only significant when fixed effects are included.[26] This positive estimate on the Pacific Northwest dummy variable indicates that shipments where barge transportation is incapable of directly competing with rail face higher per car rail costs.

While the Pacific Northwest dummy variable in Table 2 allows for railroads to price differently by destination, one could argue that the effect of distance to water would also vary by destination. To examine this possibility, Table 3 presents the results of running equation (11) with an interaction term between distance to water and the Pacific Northwest dummy variable. Tests indicate that this interaction term is not warranted meaning that railroad price based on the level of barge competition is the same regardless of destination.[27] However, it should be noted that again the estimates on the remaining coefficients are remarkably stable across specifications and when compared to those in Table 2.

5. Conclusions

The focus of this study is on the ability of railroads to spatially price discriminate under different competitive pressures, most notably, barge competition, but also competitive pressures from other markets and railroads. Using rail pricing data for corn

[26] Note that few railroads offer service to the Pacific Northwest, so the use of firm level fixed-effects is necessary to isolate the effect of shipping to the Pacific Northwest, as this allows the Pacific Northwest dummy variable to capture differences in the rates within the firm.

[27] This result points to the previous discussion that shippers chose both mode and destination, meaning that shippers are not tied to one destination and the level of barge competition is the constraining factor for railroads in their pricing decision regardless of the destination.

shipments originating from a random sample of warehouse locations that are either first or second degree contiguous to the Mississippi River System, the results indicate that increased barge competition leads to a decrease in the rail rate per car. In particular, the rail rate per car is found to be 3.1% to 6.6% higher for a warehouse located 700 miles away from the water as compared to a firm located only two tenths of a mile from the waterway, at the mean values of the other variables. In addition, rail rates are estimated to be 2.8 to 3.7 percent lower for facilities with direct barge access at their location, meaning that rates can be as much as 10.3% higher attributable solely to competition from the barge industry. Aggregated over a 50 car shipment, this implies a cost difference of $9,473 to $16,123. These results imply that, following the deregulation of the railroad industry and the subsequent merger activity, shippers who have a higher degree of "captivity" as measured by the availability of barge transportation and/or ethanol production, face a significantly higher rail rate.

Along with the contribution to the literature on modal competition and pricing, these results also call into question the assumptions behind current benefit estimation models for waterway improvements. These models typically assume that the barge market and the rail market are independent rather than interdependent, an assumption that this study directly contradicts. However, a useful extension of this present study for policy makers would be to examine the interaction between barge and rail for other commodities.

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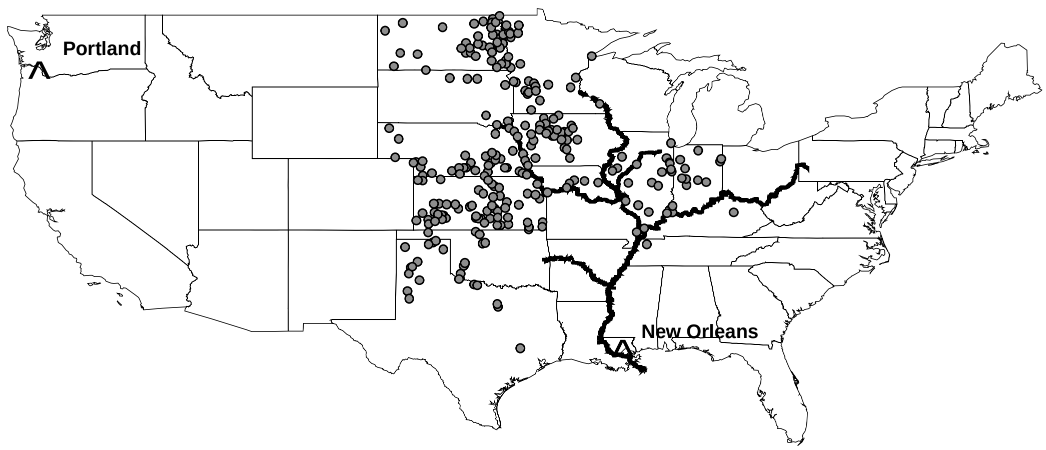

FIGURE 1: Locations of FSA Warehouses Used to Collect Rail Pricing Information

The data used for this analysis consist of a random sample of warehouses that are either first or second degree contiguous with the Mississippi River System. Information on the location of these warehouses was obtained from the Farm Service Agency (FSA).

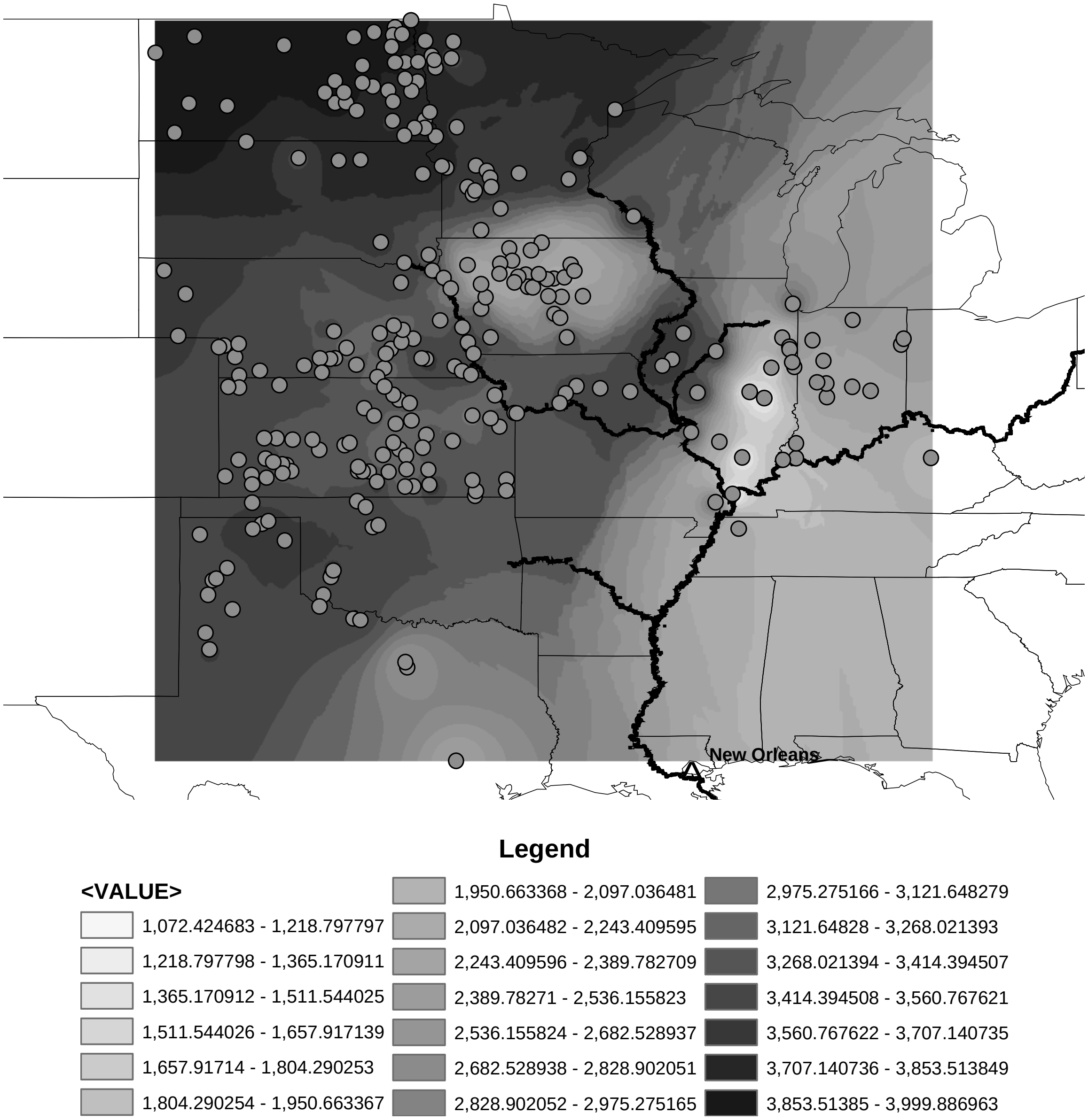

FIGURE 2: Average Rail Rate by Location

For the warehouse locations indicated in Figure 1, rail rates were collected for the shipment of corn to the Gulf Coast Region and/or the Pacific Northwest. Darker colors represent higher average rail rates.

TABLE 1: Summary Statistics of Variables

The data consist of 1144 observations on rail rates for the shipment of corn between the locations indicated in Figure 1 and either the Gulf Coast or the Pacific Northwest. Capacity is measured as the average number of tons that can be shipped at the given rate. Distance is the rail distance between the origin and the destination (either the Gulf Coast or the Pacific Northwest). Unit train is a dummy variable equal to one if the rate requires the shipment be part of a unit train. Distance to water is the mileage between each origin and the nearest grain shipping port as defined by the Army Corps of Engineers Port Facilities database. Direct barge access is a dummy variable equal to one if the origin facility has direct barge access. Rail competition is equal to the number of alternative railroads capable of both serving the origin in question and hauling corn between that origin and either the Gulf Coast or the Pacific Northwest. Ethanol Capacity is the sum of the productive capacity (measured in millions of gallons per year) for all ethanol plants located within 60 miles of the origin warehouse. Pacific Northwest is a dummy variable equal to one if the rate is for a shipment terminating in the Pacific Northwest.

Variables	Mean (Total)	Mean (Destination Pacific Northwest)	Mean (Destination Gulf Coast)	Mean (Closest 25% of Observations to Waterway)	Mean (Furthest 25% of Observations to Waterway)
Rate Per Car	$3358.6	$3834.5	$3168.9	$3175.4	$3664.2
Capacity	6327.9	4340.4	7119.9	6639.1	5683.2
Distance	1490.1	1935.7	1312.5	1411.3	1663.9
Unit Train	0.2072	0.5859	0.0562	0.2305	0.1815
Distance to Water	206.38	231.21	205.85	28.929	425.08
Direct Barge Access	0.0367	0.0307	0.0428	0.1462	0
Rail Competition	0.1021	0.1043	0.1271	0.2018	0
Ethanol Capacity	79.038	77.132	79.798	89.000	13.366
Pacific Northwest	0.2394	1	0	0.2565	0.3267

TABLE 2: Rate Per Car Regression Results

The dependent variable is the log of the rail rate per car. The railroad specific fixed effects control for systematic pricing differences across the railroad companies.

	OLS	Railroad Specific Fixed Effects
Log Capacity	-0.0641***	-0.0455***
	(0.0044)	(0.0021)
Log Distance	0.4683***	0.3474***
	(0.0127)	(0.0063)
Unit Train	-0.0899***	-0.0592***
	(0.0103)	(0.0054)
Log Distance to Water	0.0079***	0.0038***
	(0.0027)	(0.0012)
Direct Barge Access	-0.0357*	-0.0278***
	(0.0205)	(0.0094)
Rail Competition	-0.0023	0.0067
	(0.0095)	(0.0044)
Ethanol Capacity	-0.0003***	-0.00001
	(0.00003)	(0.00001)
Pacific Northwest	0.0174	0.0220***
	(0.0109)	(0.0053)
Constant	5.2433***	5.9527***
	(0.1028)	(0.0487)
R2	.74	.95
Observations	1144	1144
Number of Firms		6
F-Test for Use of Fixed Effects		F(5,1130) = 854.9***

(.) contain standard errors. A * indicates significance at the 10% level, a ** indicates significance at the 5% level and a *** indicates significance at the 1% level.

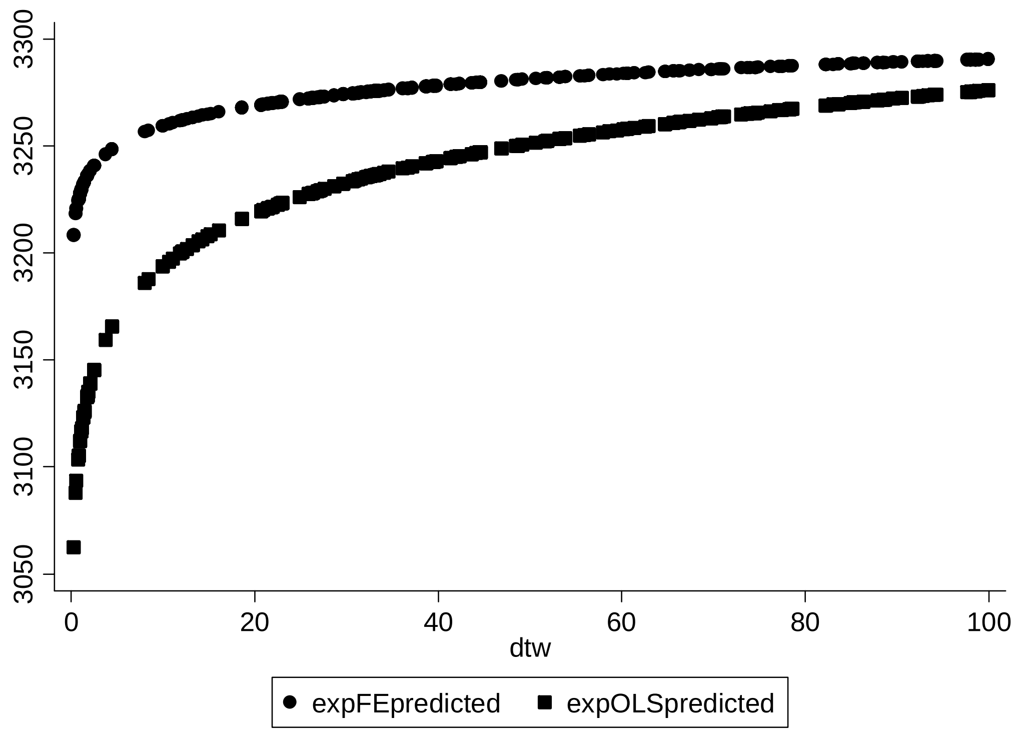

FIGURE 3: Predicted Rate Per Car From OLS and FE Specifications

Estimated rate per car from the fixed effects model presented in Table 2 at the average values of all variables except for distance to waterway for observations located within 100 miles of the waterway.

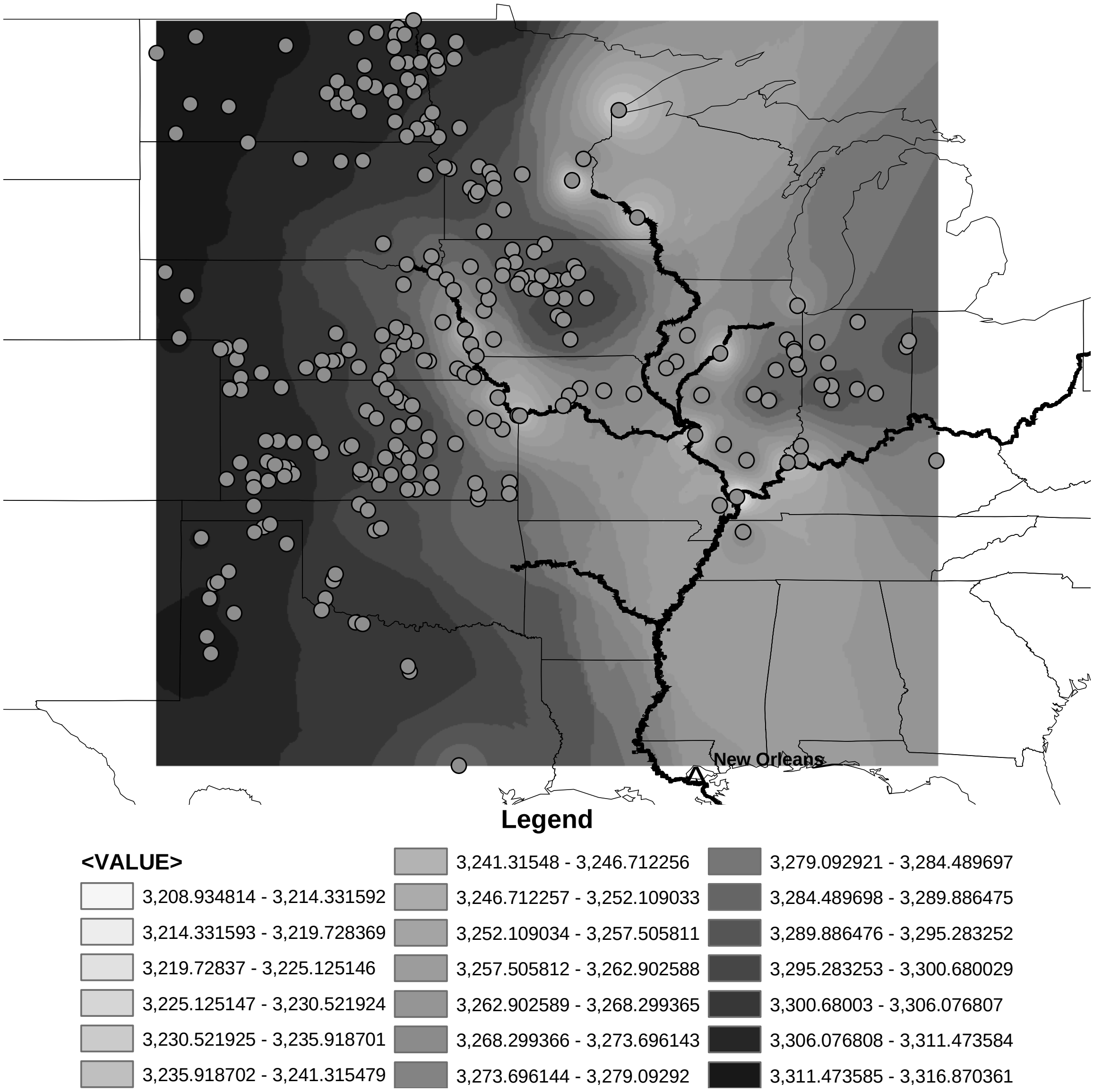

FIGURE 4: Geographic Illustration of the Effect of Distance to Water on the Predicted Rail Rate

Estimated rate per car from the fixed effects model presented in Table 2 at the average values of all variables except for distance to waterway. Darker colors represent higher predicted rail rates.

TABLE 3: Rate Per Car Regression Results with Destination Interaction

The dependent variable is the log of the rail rate per car. The railroad specific fixed effects control for systematic pricing differences across the railroad companies.

	OLS	Railroad Specific Fixed Effects
Log Capacity	-0.0640***	-0.0455***
	(0.0044)	(0.0021)
Log Distance	0.4659***	0.3488***
	(0.0129)	(0.0064)
Unit Train	-0.0900***	-0.0590***
	(0.0103)	(0.0054)
Log Distance to Water	0.0094***	0.0029**
	(0.0030)	(0.0014)
Direct Barge Access	-0.0344*	-0.0285***
	(0.0205)	(0.0094)
Rail Competition	-0.0023	0.0066
	(0.0095)	(0.0044)
Ethanol Capacity	-0.0003***	-0.00001
	(0.00003)	(0.00001)
Destination Pacific	0.0427	0.0068
Northwest	(0.0264)	(0.0124)
Pacific Northwest*Log	-0.0050	0.0030
Distance to Water	(0.0047)	(0.0022)
Constant	5.2522***	5.9479***
	(0.1031)	(0.0489)
R2	.74	.95
Observations	1144	1144
Number of Firms		6
F-Test for Use of Fixed Effects		F(5,1118) = 854.9***

(.) contain standard errors. A * indicates significance at the 10% level, a ** indicates significance at the 5% level and a *** indicates significance at the 1% level.